Infectious Complications of Noncombat Trauma Patients Provided Care at a Military Trauma Center

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ABSTRACT Infectious complications are reported frequently in combat trauma patients treated at military hospitals. Infections in 4566 noncombat related trauma patients treated at a military trauma center were retrospectively reviewed from 1/2003 to 5/2007 using registry data. Burns, penetrating, and blunt trauma accounted for 17%, 19%, and 64%, respectively; the median age was 38 and 22% were female. Pulmonary infections were present in 4.2% of patients, 2.4% had cellulitis and wound infections, 2.2% urinary infections, and 0.7% sepsis. On univariate analysis, infected patients were more likely to be admitted to the ICU, have longer ICU and hospital lengths of stay (LOS), and to die ($p < 0.05$). Multivariate analysis revealed associations between infection and hospital LOS, preexisting medical conditions, and lower Glasgow Coma Scale in nonburned patients. In burned patients, infection was associated with total body surface area burned and preexisting conditions ($p < 0.01$). Enhanced infection control in targeted trauma populations may improve outcomes.

INTRODUCTION

Infectious complications are well-recognized sources of morbidity in both civilian and combat-related trauma patients, and are leading causes of death in patients who survive the first few days after injury.[1–4] In combat-related trauma patients, infectious complications are particularly relevant as there have been over 36,000 US servicemen wounded in action during the courses of Operations Iraqi Freedom and Enduring Freedom (www.defenselink.mil/news/casualty.pdf, accessed 22 March 2010). Despite major, fundamental changes in the approach to combat casualty care over the decades, infections after war trauma have remained a leading cause of death both recently and in the Vietnam era.[5–7] Furthermore, there may be differences in infection rates described in the combat casualty setting as compared to civilian trauma settings. While the retrospective study of combat casualties enrolled in the Joint Theater Trauma Registry (JTTR) revealed cumulative infection rates approaching 35%, similarly designed studies in civilian settings using chart abstraction or infection control data to capture infectious complications describe rates from 9–13%.[8–11] It is not clear whether this is related to differences in severity of injury, population served, features of care or some other reason, but there are no previously published descriptions of infectious complications in noncombat related trauma patients treated at military medical centers. If these also have higher than typical infection rates, it could indicate unique problems related to infection control in these facilities. Although civilian trauma patients are also known to be at high risk for infection, ranging from 9–37% depending upon study design and population, the epidemiology and risk factors have not been completely explored, and outside of the combat setting there is little infection prevention guidance specific to the trauma population.[9–14] This is notable given the increased emphasis on hospital infection control in recent years, the fact that these infections typically occur several days into hospitalization, by definition are healthcare associated, and the increasing role of multidrug resistant organisms in such infections. The expectation of The Joint Commission is that any unexpected death related to a healthcare associated infection will be managed as a sentinel event, and Medicare no longer reimburses for some healthcare associated infections. For all these reasons, the impact of infectious complications in the trauma population cannot be overstated.

The purpose of this epidemiologic study was to portray a broader view of infectious complications and risk factors of noncombat trauma patients cared for in a military level I trauma center with an associated burn unit using the Brooke Army Medical Center (BAMC) Trauma Registry (BAMC TR).

MATERIALS AND METHODS

The BAMC TR is a prospectively collected administrative database of trauma patients evaluated at this facility that is part of the national trauma registry system. BAMC is a 224 bed, level I trauma center serving San Antonio, a city of 1.3 million, sharing trauma admissions between two other local facilities. It is also has a 40-bed burn unit which serves as a referral center for the local civilian population in southwest Texas and the Department of Defense. This study was approved by

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the Institutional Review Board and no informed consent was required since it was a retrospective registry study.

Data were collected on 4566 adult trauma patients (not injured during military operations in Iraq and Afghanistan) admitted from January 2003 to May 2007 and surviving at least 24 hours; these included 2922 patients with blunt trauma, 847 with penetrating trauma, and 772 with burns. Demographic information, including age, gender, preexisting medical conditions, height and weight, and ethnicity was collected. Trauma-related variables included injury severity score (ISS), admission Glasgow Coma Scale (GCS), total body surface area (TBSA) burned when relevant, mechanism of injury, transfusion in the emergency department (ED), the interval between injury and ED admission, and the interval between ED admission and ED discharge. Data were not available for evaluation at an outside facility prior to arrival in the BAMC ED. Clinical data collected include ICU admission and length of stay, hospital length of stay (LOS), and survival to discharge. Injury severity was stratified into three groups: mild (ISS <15), moderate (ISS 15–29) and severe (ISS ≥ 30).

Preexisting medical conditions were listed in the registry by ICD-9 code and bundled by the investigators into the following groups: cardiovascular disease, endocrine disease/diabetes (the level of detail provided by ICD-9 code was not reliable to separate these two categories), psychiatric disease, liver disease, malignancy, pulmonary disease, substance abuse, immunodeficiency, renal disease, gastrointestinal disease, hematologic disease, musculoskeletal disease, neurologic disease, and pregnancy.

Infectious diagnoses were captured in the trauma registry by ICD-9 code. Pulmonary infections were considered to include ICD-9 codes for pneumonia, ventilator associated pneumonia (VAP), healthcare associated pneumonia, and tracheobronchitis. Cellulitis was considered to include skin graft and donor site cellulitis as well as cellulitis not otherwise specified. Wound infections included surgical site infections as well as infections of traumatic wounds. Data on device-days were not consistently available for patients with devices related to infection such as urinary catheters, or central lines, and no rates were calculated by device-days for this reason. Yearly VAP rates were estimated by considering all reported pneumonias in ventilated patients in the study to be ventilator-associated, and dividing these by the sum of patient ventilator-days and multiplying by 1000. These were compared to yearly VAP rates collected by the hospital infection control department using the contemporaneous National Nosocomial Infections Surveillance (NNIS)/National Healthcare Safety Network (NHSN) definitions during the same time periods (2007 data were not included as the study period ended in May) as a measure of quality control. A cumulative endpoint of all infectious diagnoses was considered to be met in patients with one or more infectious ICD-9 code in the registry; patients with more than one infectious ICD-9 code were counted once.

Univariate analyses were performed to evaluate differences between infected and noninfected patients on demographic, trauma-related and clinical variables (age, gender, ISS, body mass index [BMI], mechanism of injury, preexisting medical conditions, volume of packed red cells transfused in the ED, and the intervals between both injury and ED admission, and ED admission and discharge). Univariate analyses were also performed to compare infected and noninfected patients for outcome measures (ICU admission and length of stay, hospital length of stay, mortality). The same demographic, trauma-related and clinical variables were also evaluated by univariate analyses with regard to patients who did and did not survive until discharge. Categorical variables were compared using Pearson's χ^2 analysis and continuous, nonparametric variables with Mann-Whitney U test. For multiple-group comparisons, analysis of variance was performed on normally distributed data and Kruskall-Wallis test for nonparametric data. Statistical significance was considered to be met with a two-tailed p value ≤ 0.05. Stepwise logistic regression analyses were done for associations with infection among burned and nonburned patients among variables with p values ≤ 0.05 on Spearman correlation; logistic regression was performed for associations with survival to discharge among burned and nonburned patients as well. Hosmer and Lemeshow testing was used to assess variables in regression models for goodness of fit; fit was considered adequate with a p value ≥ 0.05. Univariate and multivariate analyses were performed using SPSS version 16.0 (SPSS Inc., Chicago, IL).

RESULTS

The total number of subjects included 4566 patients (2922 blunt, 847 penetrating, and 772 burns). Demographic and clinical information for the group as a whole and for burned versus nonburned patients are presented in Tables I and II, respectively. The overall mortality rate for the group was 6.7%, and 8.2% were diagnosed with at least one infectious complication. The median LOS for the hospital and the ICU were 4 days (IQR = 7) and 0 days (IQR = 2), respectively; 46.6% were admitted to the ICU for at least one day. The most common infectious complications captured in the database were pneumonia, urinary tract infection, and cellulitis (Table III). Cumulative pneumonia rates in trauma and burned ventilated patients, respectively, are presented with hospital infection control VAP rates for the trauma and burn ICUs inFigure 1A and 1B. Clinical characteristics of each ISS group are presented in Table IV, with significant differences between the three groups in terms of hospital and ICU LOS, infection and mortality rates.

Univariate analysis of infected versus noninfected patients' demographic, clinical, and outcome variables is presented in Table V. Patients developing infection were older, had increased ISS, lower GCS, and were more likely to have at least one preexisting medical condition documented. Among these, infection was significantly associated with preexisting cardiovascular disease, psychiatric disease, and substance abuse. Among burned patients, infection was associated with increased TBSA burned. A burn mechanism of injury was

TABLE I. Demographic information for patients within the trauma registry

Variable	N (%)
Total	4566
Gender	
Male	3541 (77.5)
Female	1025 (22.4)
Race	
White	2026 (44.4)
Hispanic	1111 (24.3)
Black	411 (9.0)
Asian-Pacific	23 (0.5)
Other	990 (21.6)
Injury type	
Blunt	2922 (64.0)
Penetrating	847 (18.5)
Burn	772 (16.9)
TBSA burned %, median (IQR)	10 (16)
Age, yrs, median (IQR)	38 (25)
Injury Severity Score, median (IQR)	9 (13)
Admission Glasgow Coma Score, median (IQR)	15 (0)
Body mass index, median (IQR)	26.5 (7)
Any known preexisting medical condition	1401 (30.7)
Cardiovascular disease	682 (14.9)
Endocrine disease (including diabetes mellitus)	390 (8.5)
Psychiatric disease	224 (4.9)
Pulmonary disease	105 (2.3)
Substance abuse	100 (2.2)
Malignancy	57 (1.2)
Liver disease	41 (0.9)
Immunodeficiency	14 (0.3)
Renal disease	13 (0.3)

IQR- interquartile range; TBSA- total body surface area.

TABLE II. Demographic characteristics of burned vs. nonburned patients

Variable	Burned N (%)	Nonburned N (%)	*p* value
Total	772	3769	
Gender			NS
Male	615 (79.7)	2911 (77.2)	
Female	157 (20.3)	858 (22.8)	
Race			<0.001
White	348 (45.1)	1667 (44.2)	
Hispanic	356 (46.1)	747 (19.8)	
Black	33 (4.3)	374 (9.9)	
Asian-Pacific	3 (0.4)	20 (0.5)	
Other	31 (4.0)	959 (25.4)	
Age, yrs, median (IQR)	42 (25)	37 (24)	<0.001
Injury Severity Score, median (IQR)	4 (8)	9 (13)	<0.001
Admission Glasgow Coma Score, median (IQR)	15 (7)	15 (0)	0.006
Body mass index, median (IQR)	27 (7.5)	26 (6.9)	0.030
Any known preexisting medical condition	304 (39.4)	1082 (28.7)	0.025
Cardiovascular disease	143 (18.5)	536 (14.2)	
Endocrine disease (including diabetes mellitus)	53 (6.9)	337 (8.9)	
Psychiatric disease	46 (6.0)	177 (4.7)	
Substance abuse	43 (5.6)	56 (1.5)	
Pulmonary disease	24 (3.1)	80 (2.1)	
Liver disease	13 (1.7)	27 (0.7)	
Malignancy	7 (0.9)	49 (1.3)	
Immunodeficiency	4 (0.5)	7 (0.2)	
Renal disease	0 (0)	13 (0.3)	

NS- not significant; IQR- interquartile range.

TABLE III. Infectious complications

Total (%)*	375 (8.2)
Pneumonia	184 (4.0)
Urinary tract infection	100 (2.2)
Cellulitis	68 (1.5)
Wound infection	39 (0.9)
Sepsis	34 (0.7)
Bacteremia	33 (0.7)
Tracheobronchitis	18 (0.4)
Other**	18 (0.4)

*Number of patients with at least one infectious complication; numbers do not add up to total because some had >1 complication. **Fungemia (1), Fungal sepsis (2), Intraabdominal abscess (1), Abdominal sepsis (1), Other abscess (7), Osteomyelitis (1), Meningitis (1), Empyema (4).

associated with infection ($p < 0.001$) compared to a nonburn mechanism (15% vs. 6.6%), and there were significantly higher rates of infection among patients with blunt versus penetrating trauma (7.5% vs. 3.5%, $p < 0.001$). A shorter interval between ED admission and ED discharge was associated with infection; however, this was on the order of a median of 18 minutes. Infection was also associated with longer LOS both in the hospital and the ICU, and with increased mortality. The median interval to first infection was 7 days; only 9.8% of first infectious complications presented in the first 48 hours after admission.

Univariate analysis of demographic and clinical variables among patients who did and did not survive to discharge is presented in Table VI. Overall, mortality was associated with female gender, increased age and ISS, decreased GCS, increased TBSA among burned patients, and preexisting medical conditions, in particular cardiovascular disease, renal disease, and malignancy. There was no difference between mortality rate in patients with blunt vs. penetrating trauma, but a burn mechanism of injury was associated with a higher mortality rate compared to a nonburn mechanism (10.0% vs. 6.0%, $p < 0.001$). There was a trend toward an association with ED transfusion of packed red blood cells with mortality, but this was not significant. An association was seen with mortality and a shorter interval between both injury and ED arrival, and ED arrival and ED discharge. Associations were also noted between mortality and pneumonia, bacteremia, and sepsis, ($p < 0.01$), though not for cellulitis, urinary tract infections, or wound infections.

Because infection and mortality rates and risk factors were different between burned patients and nonburned patients, separate multivariate analyses were performed for the two groups; the results of these logistic regression models are presented in Tables VII and VIII. For nonburned trauma patients, a lower

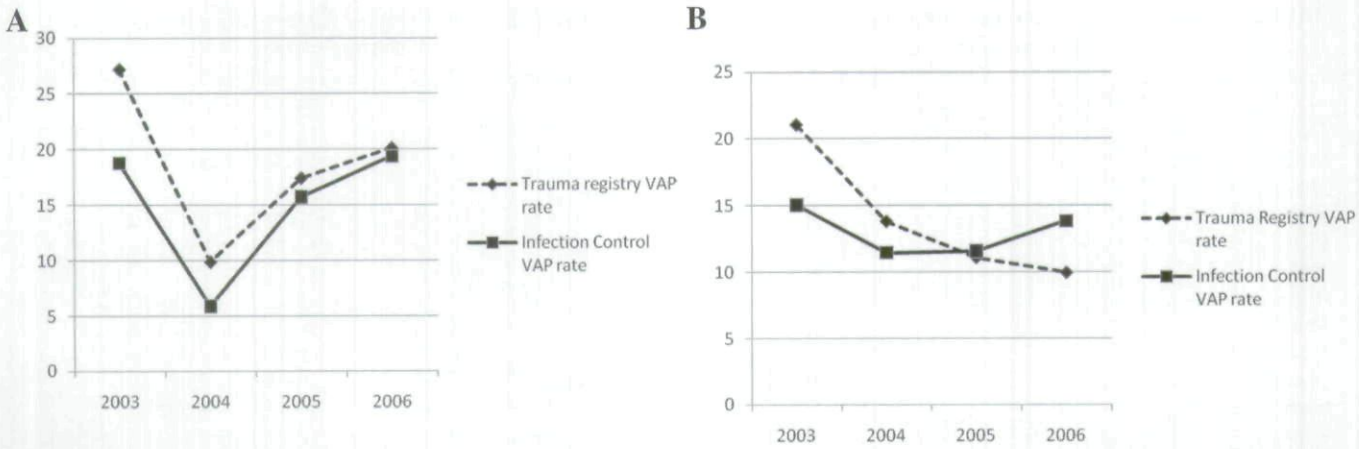

FIGURE 1. Rates of ventilator associated pneumonia (VAP) in non-burned trauma patients, and National Nosocomial Infections Surveillance/National Healthcare Safety Network defined ventilator-associated pneumonia rates in the trauma intensive care unit (A), and for burned patients and the burn intensive care unit (B). Rates are calculated using number of events/number of ventilator-days × 1000.

TABLE IV. Clinical characteristics based on Injury Severity Score (ISS) group

Variable	Mild injury ISS < 15	Moderate injury ISS 15–29	Severe Injury ISS ≥ 30	*p* value*
Number of patients (%)	3227 (70.6)	1007 (22.0)	270 (5.9)	
Age, yrs, median (IQR)	36 (23)	42 (32)	38 (26)	<0.001
ICU LOS, days, median (IQR)	0 (1)	3 (7)	4 (13)	<0.001
Hospital LOS, days, median (IQR)	3 (4)	7 (14)	8 (22)	<0.001
Infected, number (%)	137 (4.2)	171 (17.0)	60 (22.2)	<0.001
Mortality, number (%)	35 (1.1)	128 (12.7)	134 (49.6)	<0.001

*between all groups.
IQR- interquartile range; ICU- intensive care unit; LOS- length of stay.

GCS, longer hospital LOS, and the presence of a preexisting medical condition were independently associated with infection. Among burned patients, presence of a preexisting medical condition and increased TBSA were independently associated with infection. Infection was not independently associated with survival in either burned or nonburned patients. For nonburned patients, survival was associated with younger age, higher GCS, and longer time spent in the ED. Among burned patients, a lower TBSA, younger age, lower ISS, and male gender were independently associated with survival.

After injury patterns were bundled by individual Abbreviated Injury Scale (AIS) categories (head, chest, abdomen and extremity), they were assessed for their association with specific infections. Pneumonia was associated with head, chest, and extremity injuries (all $p < 0.01$). Sepsis was associated with head ($p = 0.02$) and extremity injury ($p = 0.04$). Infections of the urinary tract were associated with head ($p < 0.01$) and extremity injuries ($p = 0.04$). Wound infections were only associated with extremity injuries ($p < 0.01$). Interestingly, sepsis and urinary tract infection were not associated with chest and abdominal injury.

DISCUSSION

These data present the first systematic overview of infectious complications of trauma unrelated to war treated at a military level I trauma center. The most fundamental finding of this study is that the rates of infectious complications after trauma in this context more closely mirror those published from civilian institutions than they do those reported after combat trauma. While high rates comparable to those from the JTTR have been published, these are typically seen in prospective studies. Among 563 trauma patients admitted to one center in 1996, 37% of patients were reported to have developed at least one infection.[12] Another prospective civilian trauma study with mostly penetrating injuries (70% of 450 patients) showed a sepsis rate of 15%.[14] However, retrospective studies with similar populations to this one have revealed rates consistent with those seen here. One multicenter trauma registry study in Pennsylvania involving over 30,000 patients demonstrated a sepsis rate of 2%, with pneumonia being the primary site of infection.[13] A recent multicenter cohort study comparing complication rates among level I trauma centers to those at nontrauma centers revealed pneumonia and sepsis rates of 12% and 4.5%, respectively, among the 1,999 patients admitted to trauma centers.[15] Another evaluating late outcomes of trauma-related infection and retrospectively capturing index hospitalization infection data demonstrated that 13% of patients had at least one infectious complication; however, this study only included patients with at least one moderate to severe injury (AIS ≥ 3).[10] Finally, two registry studies using infection control

TABLE V. Comparison of infected and noninfected patients on demographic, clinical, and trauma-related variables

Variable	N*	Not infected	Infected	*p* value
No. (%)	4566	4191 (91.8)	375 (8.2)	
Gender (%)	4566			NS
Male		3253 (77.6)	288 (76.8)	
Female		938 (22.4)	87 (23.2)	
Age, median (IQR)	4528	37 (24)	43 (28)	<0.001
Injury Severity Score, median (IQR)	4504	9 (14)	18 (17)	<0.001
Body mass index, median (IQR)	1862	26.5 (7.4)	26.3 (6.4)	NS
Mechanism of injury (%)	4541			<0.001
Blunt	2922	2702 (92.5)	220 (7.5)	
Penetrating	847	817 (96.5)	30 (3.5)	
Burn	772	654 (84.7)	118 (15.3)	
TBSA burned, %, median (IQR)		8 (13)	19 (26)	<0.001
Admission Glasgow Coma Scale, median (IQR)	4251	15 (0)	15 (12)	<0.001
Preexisting medical condition (%)	3677	3398	279	
Any		1243 (36.6)	158 (56.6)	<0.001
Cardiovascular disease		618 (18.2)	64 (22.9)	0.0496
Endocrine disease (including diabetes mellitus)		356 (10.5)	34 (12.2)	NS
Psychiatric disease		191 (5.6)	33 (11.8)	<0.001
Pulmonary disease		95 (2.8)	10 (3.6)	NS
Substance abuse		80 (2.4)	20 (7.2)	<0.001
Malignancy		52 (1.5)	5 (1.8)	NS
Liver disease		36 (1.1)	5 (1.8)	NS
Immunodeficiency		14 (0.4)	0 (0)	NS
Renal disease		11 (0.3)	3 (0.1)	NS
Packed red cells transfused in the ED, mL, median (IQR)	208	712 (552)	850 (675)	NS
Interval between injury and ED, hours, median (IQR)	3446	1.4 (3.7)	1.5 (4.3)	NS
Interval between ED admission and ED discharge, hours, median (IQR)	3985	1.4 (1.9)	1.1 (0.8)	<0.001
Interval until 1st infection, days, median (IQR)	235	N/A	7 (8)	
ICU days, median (IQR)		0 (2)	12 (21)	<0.001
Hospital days, median (IQR)	4560	3 (5)	22 (30)	<0.001
Mortality	311	265 (6.3)	46 (12.2)	<0.001

*patients with data for variable studies.
NS- not significant; TBSA- total body surface area; IQR- interquartile range; ED- emergency department.

data to define infection revealed rates of 9%, very consistent with those seen here.[9,11] We were able to compare estimates of ventilator-associated pneumonia (VAP) rates in the registry population to those collated by infection control as a measure of quality control. Obviously, there are limitations to this comparison; ours were estimates and did not use the NHSN definition employed by the infection control department, but the very similar numbers and trends are reassuring as a cross-check. Taken together, our infection rates reported here seem consistent with both logic and preexisting literature.

However, retrospective data published from the JTTR revealed that approximately one third of patients developed at least one infectious complication, even under a relatively conservative definition requiring both an anatomic or clinical syndrome and a pathogen.[8] The design of this study was similar, and many patients enrolled in the JTTR were cared for at this institution, and yet the rates of infectious outcomes are quite disparate from our nonmilitary cohort described herein. This is particularly notable since this study and others have consistently revealed advanced age and underlying medical conditions to be risk factors for infection, and since the combat injured population is generally without serious comorbidities, with a median age of 26, approximately twelve years younger than this study's population.[16] However, the average ISS for the patients in JTTR study was 15 (military AIS 20), compared to a median of 9 in our study. It is likely that the severity of injury is the primary factor driving these differences in rates. Another possible contributor is timing of definitive surgical procedures. Standard, modern combat casualty surgical care frequently involves damage control, which takes place across multiple levels of care and can have a prolonged time course from injury to definitive surgery.[17] Delayed timing of surgical procedures, very infrequently reported in the BAMC trauma registry, and damage control surgery have both been associated with infectious complications.[12,18] Finally, concerns have been raised about infection control procedures in deployed medical treatment facilities, and significant variability exists from one deployed facility to another.[19] This may be an additional explanation for the higher infection rates seen in the JTTR compared to the BAMC TR, as BAMC has a stable infection control program with consistent emphasis on hand hygiene and other preventive measures. Exploration and thoughtful consideration of these differences is necessary not only for optimal patient care, but for appropriate education of

TABLE VI. Comparison of patients who did and did not survive until discharge by demographic, clinical, and trauma-related variables

Variable	N*	Did not survive to discharge	Survived to discharge	*p* value
No. (%)	4566	311 (6.8)	4255 (93.2)	
Gender (%)	4566			0.023
Male		225 (72.3)	3316 (77.9)	
Female		86 (27.7)	939 (22.1)	
Age, median (IQR)	4528	49 (41)	37 (24)	<0.001
Injury Severity Score, median (IQR)	4504	29 (12)	9 (12)	<0.001
Body mass index, median (IQR)	1862	25.8 (7.6)	26.5 (7.1)	NS
Mechanism of injury	4541			<0.001
Blunt	2922	179 (6.1)	2743 (93.9)	
Penetrating	847	49 (5.8)	798 (94.2)	
Burn	772	77 (10.0)	695 (90.0)	
TBSA burned, %, median (IQR)		52 (52)	8 (12)	<0.001
Admission Glasgow Coma Scale, median (IQR)	4251	3 (5)	15 (0)	<0.001
Preexisting medical condition (%)	3677	238	3439	
Any		119 (50.0)	1282 (37.3)	<0.001
Cardiovascular disease		82 (34.5)	600 (17.4)	<0.001
Endocrine disease (including diabetes mellitus)		24 (10.1)	366 (10.6)	NS
Psychiatric disease		17 (7.1)	207 (6.0)	NS
Liver disease		3 (1.3)	38 (1.1)	NS
Malignancy		9 (3.8)	48 (1.4)	0.004
Pulmonary disease		10 (4.2)	95 (2.8)	NS
Substance abuse		7 (2.9)	93 (2.7)	NS
Immunodeficiency		2 (0.8)	12 (0.3)	NS
Renal disease		6 (2.5)	7 (0.2)	<0.001
Packed red cells transfused in the ED, mL, median (IQR)	208	1000 (700)	700 (700)	0.053
Interval between injury and ED, hours, median (IQR)	3446	1.1 (3.2)	1.4 (3.9)	0.002
Interval between ED admission and ED discharge, hours, median (IQR)	3985	0.8 (0.8)	1.4 (1.8)	<0.001

*patients with data for variable studies.
NS- not significant; ED- emergency department; TBSA- total body surface area; IQR- interquartile range.

TABLE VII. Logistic regression models for risks associated with infection among burned and nonburned patients

	Odds ratio	Confidence interval	*p* value
Nonburned			
Injury Severity Score	1.02	1.00–1.03	NS
Hospital length of stay*	6.53	5.08–8.38	<0.001
ED length of stay	0.92	0.77–1.10	NS
Age	1.00	0.99–1.02	NS
Preexisting conditions	1.94	1.31–2.88	0.001
Substance abuse	1.54	0.53–4.53	NS
Glasgow Coma Scale	0.94	0.90–0.98	0.002
Mechanism of injury	1.19	0.66–2.14	NS
Burned			
Injury Severity Score	1.00	0.96–1.03	NS
Hospital length of stay*,**	3.07	2.28–4.13	<0.001
Total body surface area*	1.89	1.53–2.33	<0.001
Age	1.01	0.99–1.02	NS
Preexisting conditions	2.89	1.86–4.49	<0.001
Cardiovascular disease	0.49	0.22–1.12	NS
Substance abuse	0.49	0.15–1.60	NS
Glasgow Coma Scale	0.98	0.92–1.03	NS

*Natural logarithm was used to transform these variables due to skewness.
**Using Hospital length of stay did not pass the goodness of fit test.
ED- emergency department.

TABLE VIII. Logistic regression models for risks associated with survival to discharge among burned and nonburned patients

	OR	CI	*p* value
Nonburned			
Injury Severity Score*	0.90	0.84–0.96	0.001
Hospital length of stay*	1.16	1.05–1.29	0.004
ED length of stay	2.16	1.64–2.84	<0.001
Age	0.97	0.96–0.98	<0.001
Preexisting conditions	0.57	0.10–3.23	NS
Glasgow Coma Scale	1.34	1.30–1.38	<0.001
Infection	1.86	0.08–46.2	NS
PRBC in ED	1.00	1.00–1.00	NS
Burned			
Injury Severity Score	0.91	0.87–0.95	<0.001
Total body surface area**	0.23	0.11–0.49	<0.001
Age	0.92	0.90–0.94	<0.001
Preexisting conditions	1.43	0.44–4.57	NS
Cardiovascular disease	1.10	0.36–3.41	NS
Endocrine disease	0.62	0.18–2.19	NS
Glasgow Coma Scale	1.08	1.00–1.17	NS
Infection	0.57	0.24–1.36	NS
Male gender	2.38	1.08–5.22	0.03

Odds ratio and confidence interval.
*Using Injury Severity Score and hospital length of stay did not pass the goodness of fit test for the nonburned regression model. **Natural logarithm was used to transform total body surface area due to skewness.
PRBC- packed red blood cells; ED- emergency department.

military medical personnel who train in stateside facilities but practice combat casualty care in austere environments.

The demographics and most common sites of infection seen in our study also more closely reflected those seen in other studies of civilian trauma than they did the JTTR, not surprisingly. The BAMC TR included 77% males while 96% of the JTTR population were male. The gender ratio in the previously discussed civilian studies ranged from 47–74%. The median ISS in the BAMC TR was 9, while that of the JTTR was 15, with civilian studies ranging from 13–24. Blunt trauma accounted for 64% of injuries in the BAMC TR while approximately 20% of injuries in the JTTR population were blunt in nature. In all the civilian studies, pneumonia was the most common site of infection, as it was in the BAMC TR; however, skin and wound infections were most common in the JTTR. Risk factors for infection seen in the BAMC TR more closely reflected those reported in other studies of civilian trauma as well; the JTTR reported risk factors for infection that generally are not relevant to civilian trauma, such as "bomb" and "landmine" as injury mechanisms.[8–15]

Lastly, any epidemiological survey of this nature finds utility in the revelation of modifiable risk factors or high-risk target groups for further study and interventions. It is interesting that on multivariate analysis for nonburned patients, hospital length of stay was more strongly associated with infection than ISS, which was highly correlated with length of stay, and fell out of the final model. Many studies have established ISS as a major risk factor for infection, though not all of these have also evaluated length of stay.[9,10,13,20] Given that a prolonged hospital stay is both an effect of and a risk factor for healthcare associated infection, it is plausible that this is more strongly associated than ISS, and serves as a reminder that trauma related infections in hospitalized patients are by nature also healthcare associated infections. Other associations with infection were preexisting medical conditions for both burned and nonburned trauma patients, low GCS for nonburned patients, and high TBSA for burned patients. Since these are identifiable on hospital admission of the trauma/burn patient, they can serve to risk stratify this population for novel or enhanced infection prevention interventions. There are many potentially useful but inadequately studied infection control strategies for these highest-risk patients including chlorhexidine baths, active surveillance and decolonization for methicillin-resistant *Staphylococcus aureus*, and a variety of promising technologies in endotracheal tubes. Given the ongoing, extremely high rates of infection in moderately to severely injured patients even in this retrospective registry study (17–22% among 1277 patients with an ISS of 15 or above) this would be the ideal population for studies involving infection control, especially since standardized infection control data are generally already captured for this group.

In conclusion, to our knowledge this is the first broad description of infectious complications in noncombat trauma patients at a US military level I trauma center. Overall rates of infection were similar to those described in civilian trauma centers, and were considerably lower than published rates among combat casualties. As these infections are nearly always healthcare associated, occurring at least 48 hours after admission in over 90% of our cohort, but vary tremendously in incidence depending on factors such as GCS, hospital length of stay, preexisting medical conditions, and TBSA for burn patients, targeted studies of enhanced infection prevention strategies are both warranted and likely to be fruitful. In the meantime, scrupulous attention to proven strategies is important in all trauma populations.

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